PERFORMANCE OF POROUS ASPHALT INCORPORATING CELLULOSE FIBER

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Asphalt berliang (PA) mempunyai struktur lapisan terbuka berbanding campuran asfalt padat. Oleh itu, PA boleh meningkat keselamatan semasa hujan kerana air struktur terbukanya. Tetapi, PA mempunyai kelemahan dari segi kestabilan dan ketahanan kerana jumlah besar lompang udara. Oleh itu, dalam kajian ini, selulosa Fiber (CF) akan bercampur dengan pengikat untuk memperbaiki sifat-sifat PA dan jenis CF digunakan adalah dalam jenis pelet. CF dikenali sebagai agen penstabil yang mempunyai kandungan asfalt yang lebih tinggi, lapisan filem tebal dan kestabilan campuran yang lebih tinggi. Oleh itu, CF mempunyai keupayaan untuk meningkatkan kekuatan PA. Kajian ini memberi tumpuan kepada kewujudan CF dalam mengikuti perintah 0% (sebagai sampel tidak diubahsuai), 0.2%, 0.3%, 0.4%, 0.5% dan 0.6% .Tujuan kajian ini adalah untuk mengkaji kesan CF pada sifat kejuruteraan PA penggredan B. Antara ujian makmal yang terlibat untuk menilai prestasi CF-PA adalah lelasan, Marshall Kestabilan, Resilient Modulus dan Dinamik Creep. Ujian lelasan untuk menilai permukaan kekuatan CF dan PA mengikat bersama-sama dengan bitumen dan hasilnya menunjukkan kekuatan permukaan yang lebih tinggi pada penambahan 0.4% CF. Untuk ujian kestabilan, ia dinilai beban maksimum boleh digunakan untuk PA sebelum kegagalan berlaku dan ia dipengaruhi oleh ketumpatan PA. Oleh itu, hasil ujian menunjukkan pada nilai yang lebih tinggi kestabilan dan ketumpatan pada penambahan 0.6% CF. Selain itu, ujian modulus yang berdaya tahan menentukan bagaimana CF dipengaruhi oleh beban trafik dan keadaan suhu. Oleh itu, hasilnya pada 0.6% CF nilai yang lebih tinggi modulus berdaya tahan pada loading lalu lintas dan keadaan suhu. Akhir sekali, ujian prestasi bagi rayapan dinamik untuk menentukan rintangan campuran asfalt untuk aluran di 25˚C dan sampel yang terbaik pada 0.2% CF. Oleh itu, kewujudan CF mampu meningkatkan prestasi PA. Untuk kajian masa depan, ia mencadangkan untuk menganalisis kelakuan mekanikal dan mikrostruktur PA dengan kewujudan CF dalam jenis bentuk yang longgar untuk dikenali mereka stabil di PA.

ABSTRACT

Porous Asphalt (PA) has an open structure layer compared to dense asphalt mixture. Thus, PA can increased the safety during rainfall due to its open structure water. But, PA have weakness in terms of stability and durability due to large amount of air voids. Therefore, in this study, Cellulose Fiber (CF) were mix with the binder to improve the properties of PA and the type of CF used was in pellets type. CF known as a stabilizing agent that have higher asphalt content, thick film coating and higher mix stability. Thus, CF has ability to improve the strength of PA. This study focuses on the existence of CF in following order 0% (as a unmodified sample), 0.2%, 0.3%, 0.4%, 0.5% and 0.6%.The aim for this study is to investigate the effect of CF on engineering properties of PA grading B. The laboratory test involved to evaluate the performance of CF-PA were Abrasion, Marshall Stability, Resilient Modulus and Dynamic Creep. The Abrasion test to evaluate surface strength CF and PA bind together with asphalt binder and the result shows that higher surface strength at the addition of 0.4% CF. For the stability test, it to evaluated the maximum load can applied to PA before failure happened and it influenced by the density of PA. Therefore, the result of testing shows at higher value of stability and density at addition of 0.6% CF. Moreover, the resilient modulus test determine how CF influenced by traffic loading and temperature condition. Thus, the result at 0.6% CF the higher value of resilient modulus at traffic loading and temperature condition. Lastly, the performance test for dynamic creep to determine the resistance of asphalt mixture to rutting at 25˚C and the best sample at 0.2% CF. Thus, the existence of CF is capable enhancing the performance of PA. For the future study, it is recommend to analyze the mechanical behavior and microstructural of PA with existence of CF in type of loose form in order to known their stabilizing in PA.

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LIST OF ABBREVIATIONS

HMA	Hot Mix Asphalt
DGA	Dense Graded Asphalt
SMA	Stone Mastic Asphalt
PA	Porous Asphalt
CF	Cellulose Fiber
SF	Steel Fiber
GF	Glass Fiber
SP	Synthetic Fiber
JKR	Jabatan Kerja Raya
DBC	Design Binder Content
LA	Los Angeles
BST	Bituminous Surface Treatment
PMA	Polymer Modified Asphalt
FKASA	Fakulti Kejuruteraan Awam & Sumber Alam
UMP	Universiti Malaysia Pahang
ASTM	American Society for Testing & Material
UTM	Universal Testing MAchine

CHAPTER 1

INTRODUCTION

1.1 Introduction

Hot mix asphalt (HMA) or asphaltic concrete are the commonly used in Malaysia for design the roads. HMA consists of two basic ingredients which as aggregate and asphalt binder or bitumen. The process of HMA is to determine the gradation aggregate, optimum asphalt binder and the optimum combination of aggregate and asphalt binder ought to be. The minerals aggregate consists of coarse and fine particles as the structural skeleton of the pavement. The bitumen normally used in construction road and highways to bind together the graded minerals (Al-Hdabi, 2016). The aggregate and asphalt binder are highly sensitivity to manage compared with other materials used in construction pavement (Abtahi et al., 2009).

The type of pavement is flexible pavements and rigid pavements and in Malaysia, flexible pavement commonly used in road construction. There are three layers of flexible pavement which is surface course, base course and sub-base course. In surface course are divide into three type of surface. It is Dense Graded Asphalt (DGA), Stone Mastic Asphalt (SMA), and Porous Asphalt (PA). PA is a type of mixture that consists of relative coarse aggregate that bound together with a sand, filler, and bitumen. PA is construct to improve the pavement of skid resistance during raining, reduce splashing effect and produce lower rising noise (Liu Q & Cao. D, 2009). This is because the interconnected voids allow the rainwater to be store and move horizontally in the PA mixture.

Nowadays, there are many research or study trying added new additives either into the asphalt binder or in the asphalt mixture to improve the properties of asphalt mixtures such as their stability and durability (H. Chen & Q. Xu, 2010). Therefore, with adding the fibers into the asphalt binder or asphalt mixtures to ensures the stability and mechanical strength of asphalt mixtures (R. Xiong et al., 2015). There are many types of fiber has been used in asphalt mixture such as Cellulose Fiber (CF), Steel Fiber (SF), Glass Fiber (GF), Synthetic Polymer (SP) and Recycle Tire Fiber (M. Manosalvas et al., 2016). The common type of fiber used as a additive in asphalt mixtures is CF. The benefits of CF as the stabilizing agent are had higher asphalt content, thick film coating and higher mix stability.

M. Mohammed et al., (2018) claims that due to the correct of quantity fiber used in the asphalt mixtures, the asphalt mixtures properties would change such as reduces the penetration, increase the softening point and at the same time, the bitumen of viscoelasticity also change. Besides that, the existence of fiber into the asphalt mixture shows that increasing the dynamic modulus of asphalt mixtures, reducing the thermal susceptibility. Thus, it can enhance the material strength, ductility and fatigue behaviour. Moreover, there are several research claims that addition of fiber into asphalt mixtures in PA reduce the drain down problems (V.C. Andres-Valeri et al., 2018)

1.2 Problem Statement

As known, Malaysia is one country that heading towards infrastructure development and Malaysia is having two condition which are having higher temperature and having heavy rainfall throughout the year. Thus, it leads the risks towards the progressive waterproofing of soil and reduce the area for water infiltration. The hydrologic factors will affects by increasing the surface runoff. In PA mixtures, the water that penetrate sometimes remains in the structure and indirectly it kept the asphalt mixtures in wet condition for a long time. Therefore, the mixture moisture can cause a damage in PA by stripping the asphalt binder from the aggregate surface. Besides that, the asphalt concrete also facing a lot of division such as rutting and stripping. The damages in asphalt pavement such as rutting occurred when a temperature changed (Kandhal Prithvi S. & Allen Cooley Jr L., 2008). Indeed, rutting can affect operation of safety when it reaches critical depths (Ali, 2006). The rainfall will leads to the accident and traffic congestion due to the water ponding above the pavement. Thus, it cause the skidding and splashing. Besides that, they are expose to heavy traffic loading and will effect the performance asphalt mixture in terms of its resilient modulus and rutting resistance.

Yusoff et al., (2014) explored due to increase to traffic volume use of heavier axle load, new axle configuration and higher tire pressure, the demand on highway pavement and asphalt layers have increased, required to enhance the performance of asphaltic materials. Therefore, the method to overcome this problem is modifying the asphalt binder properties. Since fiber composite tends to provide improvement of properties for materials, these studies intended to promote Cellulose Fiber (CF) as asphalt binder modified in order to enhance the properties of asphalt mixture.

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